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(54) [TITLE OF THE INVENTION]
Reticle and its fabrication method

(57) [Abstract]
[Objective]
To fabricate a reticle easily with high precision in lithography using vacuum ultraviolet radiation.

[Configuration]

Electron-beam photo sensitive-resist 12 with a permeability of about 0% to an ArF excimer laser (193 nm) is coated on quartz substrate 11, then a predetermined pattern is drawn on Electron-beam photo sensitive-resist 12, and it is developed to form a resist pattern. The resist pattern thus formed can be used as a reticle in ArF excimer laser lithography, and the reticle can be formed easily with high-precision. ArF excimer laser 15 is irradiated on a reticle on which a resist is pattern-formed, then ArF photo sensitive resist 14 on Si substrate 13 is exposed, and a predetermined pattern can be transcribed with high-contrast.

[WHAT IS CLAIMED]

[Claim 1]

A reticle comprising a structure with a resist pattern on a glass substrate.

[Claim 2]

A reticle described in Claim 1, characterized in that said resist pattern is not permeated by vacuum ultraviolet radiation.

[Claim 3]

A fabrication method for a reticle, comprising the steps: coating a resist on a glass substrate to expose said resist, and developing said resist.

[Claim 4]

A fabrication method for the reticle described in Claim 3, characterized in that said resist is not permeated by vacuum ultraviolet radiation.

[Claim 5]

A fabrication method for the reticle described in Claim 3, characterized in that the pattern used in said

step for exposing the resist is drawn using an electron beam.

[Claim6]

A fabrication method for the reticle described in Claim 3, characterized in that a step in which said resist is heat-treated is added after said step for developing the resist.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Application Field of the Invention]

This invention relates to photolithography technology for minute-processing of semiconductor devices, in particular, to the structure of a reticle and its fabrication method of the reticle in photolithography using vacuum ultraviolet radiation as a light source.

[0002]

[Prior Art]

Photolithography technology is indispensable in mass producing LSIs because of its high throughput and because a minute pattern can be formed by using a reticle to contract-project a pattern with step and repeat. The resolution of R in photolithography has a related expression of $R = K1\lambda/NA$. Here, the wavelength of light is λ, and the numerical aperture is NA. However, K1 is a constant that depends on the resist material and the process. From this related expression, we know that photolithography using a light source with a shorter wavelength is necessary as the process becomes finer. At present, ULSIs are developed using a stepper as a light source of I rays (365 nm) or KrF excimer laser (248 nm). To develop finer ULSIs, a stepper using a light source with a shorter wavelength (vacuum ultraviolet region) will

become indispensable. A stepper using an ArF excimer laser (193 nm) is a possible solution. On the other hand, as miniaturization continues, the production cost of reticles increases and the processing precision of a reticle becomes more difficult.

[0003]

The conventional structure of a reticle is a thin-film of Cr laminated on the shaded part on a glass substrate. A conventional fabrication method for a reticle is shown in Figure 5. Thin Cr film 51 is laminated on quartz substrate 11 with a thickness of 80 nm. Electron-beam photo sensitive-resist 12 is laid down on said thin Cr film 51 with a thickness of 500 nm (Figure 5 (a)). An arbitrary pattern is drawn on Electron-beam photo sensitive-resist 12 and then developed (Figure 5 (b)). Thin Cr film 51 is etched using pattern-formed Electron-beam photo sensitive-resist 12 as a mask, and using an etchant in which ammonium cerous nitrate and perchloric acid are dissolved. Electron-beam photo sensitive-resist 12 is then removed by using isotropic dry etching with O_2 plasma, and a reticle is formed.

[0004]

[Problems to be Solved by the Invention]

For said structure, production costs have increased because reticle fabrication requires many steps: thin Cr film lamination, electron-beam lithography, wet etching, and resist removal. Furthermore, during wet etching of the thin Cr film, processing precision of a reticle cannot be negligible as miniaturization has continued because a dimensional shift is caused between the resist pattern dimension and finally-formed Cr pattern as a characteristic of isotropic etching.

[0005]

This invention is to solve said problems and its objective is to provide a fabrication method for a reticle with fewer fabrication steps with high precision in lithography in the vacuum ultraviolet region.

[0006]

[Means for Solving the Problem]

This invention is to provide a reticle comprising a structure of a resist pattern on a glass substrate. In particular, this invention provides said reticle characterized in that said resist pattern is not permeated by vacuum ultraviolet radiation. Furthermore, this invention is to provide a reticle fabrication method comprising the following steps: a coat of resist is laid down on a glass substrate, said resist is exposed, and then developed. In particular, this invention provides said reticle fabrication method characterized in that said resist is not permeated by vacuum ultraviolet radiation. Even more desirable, this invention is to provide said reticle fabrication method characterized in that during resist exposure, drawing is done using an electron beam. Furthermore, this invention provides said reticle fabrication method characterized in that a step is added in which said resist is heat-treated after a step developing a resist.

[0007]

[Operation]

In this invention, a reticle is fabricated by forming a resist pattern through the following steps: coating a substrate with a resist, which is not permeated by vacuum ultraviolet radiation, exposing the resist, and then, developing it. Because the resist pattern is not permeated by vacuum ultraviolet radiation, this resist pattern can act as a shaded part of a reticle in photolithography using vacuum ultraviolet radiation. That is, the reticle which was formed with a resist pattern

that is not permeated by vacuum ultraviolet radiation can be pattern-transferred with high-contrast, similar to a conventional reticle fabricated with a thin Cr film. Consequently, in contrast to the conventional fabrication steps comprising four steps of thin Cr film lamination, electron-beam lithography, wet etching, and resist removal, the fabrication method in this invention has only one electron-beam-lithography step, thus using fewer steps than the conventional fabrication method. Furthermore, processing precision is bad because the dimensional shift is caused between the resist pattern dimension and the finally-fabricated Cr pattern during the wet etching step of a thin Cr film as a characteristic of isotropic etching in the conventional method. In this invention, a reticle of higher precision can be fabricated because there is no etching step. Furthermore, in this invention, damage caused by irradiation of vacuum ultraviolet radiation is prevented because the resist pattern is hardened by heat-treating the resist pattern fabricated on a glass substrate.

[0008]

Consequently, the use of this invention efficiently operates a fabrication method more easily with high-precision.

[0009]

[Embodiment]

Next, one embodiment of the fabrication method for a reticle in this invention is described referring to drawings. Here, a reticle structure and its fabrication method are described for photolithography using vacuum ultraviolet radiation specifically an ArF excimer laser.

[0010]

Figure 1 shows the structure of a reticle and an exposure method using an ArF excimer laser—an embodiment of this invention. In the structure of the reticle, Electron-beam photo sensitive-resist 12 is pattern-formed on quartz substrate 11. In the ArF excimer laser exposure method, ArF excimer laser 15 is irradiated on reticle 16 of said structure to be pattern-transferred on ArF photo sensitive resist 14 coated on Si substrate 13. Characteristics of the ultraviolet permeability of above-described Electron-beam photo sensitive-resist 12 and ArF photo sensitive resist 14 are shown in Figure 2. As shown in the drawing, Electron-beam photo sensitive-resist 12 with a permeability of about 0% to ArF (193 nm) and ArF photo sensitive resist 14 with a permeability of about 80% to ArF (193 nm)are used. As a result, high-contrast transfer in ArF excimer laser lithography is possible by selecting a material for Electron-beam photo sensitive-resist 12 which cannot be permeated by ArF (193 nm).

[0011]

Figure 3 shows a cross-sectional view of the steps for fabricating the reticle in the first embodiment of this invention. As shown in Figure 2, Electron-beam photo sensitive-resist 12 having a permeability of about 0% to ArF (193 nm) is coated on quartz substrate 11 with a thickness of 500 nm, and Electron-beam photo sensitive-resist 12 is heat-treated for 60 seconds at 90°C (Figure 3 (a)). The electron beam is irradiated on Electron-beam photo sensitive-resist 12, which is coated on quartz substrate 11. Then a predetermined pattern is drawn. Next, Electron-beam photo sensitive-resist 12 is developed to form a resist pattern, and a reticle is fabricated (Figure 3 (b)).

[0012]

As described above, the resist pattern fabricated on the quartz substrate is not permeated by the ArF excimer laser in this embodiment, so this resist pattern acts as a shaded part of the reticle in photolithography using the ArF excimer laser. That is, the reticle, which is formed with a resist pattern not permeated by the ArF excimer laser in this embodiment can be pattern-transferred with high-contrast, similar to a conventional reticle fabricated by a thin Cr film. Consequently, in contrast to conventional fabrication steps comprising four steps of thin Cr film lamination on the quartz substrate, pattern formation by electron-beam lithography, wet etching of a thin Cr film, and resist removal, the fabrication method in this embodiment has only one pattern formation step of electron-beam lithography, and thus fewer steps than the conventional fabrication method. Furthermore, although there is a problem that the processing precision is bad because the dimensional shift is caused between the resist pattern dimension and the finally-fabricated Cr pattern in the wet etching step of a thin Cr film as a characteristic of isotropic etching in the conventional method, a reticle can be fabricated without the problem of dimensional shift with higher precision because there is no etching step in this embodiment.

[0013]

For this embodiment, a structure of a reticle and its fabrication method are shown for photolithography using vacuum ultraviolet radiation, in particular, an ArF excimer laser (193 nm) is used as the light source. Here, light with a different wavelength can be used in a similar way if the resist, which is pattern-formed on the quartz substrate, has a permeability of about 0% to the light used as the light source. Although electron-beam lithography is used to form the resist pattern on the quartz substrate in this embodiment, photolithography can be used if the permeability of the resist to the light

used as the light source for pattern transfer for this reticle is about 0%. Furthermore, although quartz is used as the substrate in this embodiment, other glass materials can be used if the permeability to the light used as the light source for pattern transfer for this reticle is sufficiently high.

[0014]

Figure 4 shows a cross-sectional view of the steps for fabricating the reticle in the second embodiment of this invention. As shown in Figure 2, Electron-beam photo sensitive-resist 12 having a permeability of about 0% to ArF (193 nm) is coated on quartz substrate 11 with a thickness of 500 nm, and Electron-beam photo sensitive-resist 12 is heat-treated for 60 seconds at 90°C (Figure 4 (a)). Electron beam is irradiated on Electron-beam photo sensitive-resist 12, which is coated on quartz substrate 11. Then a predetermined pattern is drawn. Next, Electron-beam photo sensitive-resist 12 is developed to form a resist pattern (Figure 4 (b)). Extreme ultraviolet radiation 41 is irradiated on pattern-formed Electron-beam photo sensitive-resist 12, and then, Electron-beam photo sensitive-resist 12 is heat-treated for 120 seconds at 200°C. Afterwards, Electron-beam photo sensitive-resist 12 is hardened to fabricate a reticle (Figure 4 (c)).

[0015]

As described above, the resist pattern fabricated on the quartz substrate is not permeated by the ArF excimer laser in this embodiment, so this resist pattern acts as a shaded part of the reticle in photolithography using the ArF excimer laser. That is, the reticle, which is formed with a resist pattern not permeated by the ArF excimer laser in this embodiment can be pattern-transferred with high-contrast, similar to a conventional reticle fabricated by a thin Cr film. Consequently, in contrast

to the conventional fabrication method comprising four steps of thin Cr film lamination on the quartz substrate, pattern formation by electron-beam lithography, wet etching of a thin Cr film, and resist removal, the fabrication method in this embodiment has only one pattern formation step by electron-beam lithography, and thus fewer steps than the conventional fabrication method. Furthermore, although there is a problem that the processing precision is bad because the dimensional shift is caused between the resist pattern dimension and the finally-fabricated Cr pattern in the wet etching step of a thin Cr film as a characteristic of isotropic etching in the conventional method, a reticle can be fabricated without the problem of dimensional shift with higher precision because there is no etching step in this embodiment. Furthermore, there is no damage caused by irradiation of vacuum ultraviolet radiation, so a reticle reliability is improved because extreme ultraviolet radiation is irradiated on the resist to harden the resist pattern after a resist pattern is fabricated in this embodiment.

[0016]

For this embodiment, a structure of a reticle and its fabrication method are shown for photolithography using vacuum ultraviolet radiation, in particular, an ArF excimer laser (193 nm) is used as the light source. Here, light with a different wavelength can be used in a similar way if the resist, which is pattern-formed on the quartz substrate, has a permeability of about 0% to the light used as the light source. Although electron-beam lithography is used to form the resist pattern on the quartz substrate in this embodiment, photolithography can be used if the permeability of the resist to the light used as the light source for pattern transfer of this reticle is about 0%. Furthermore, although quartz is used as the substrate in this embodiment, other glass materials

can be used if the permeability to the light used as the light source for pattern transfer for this reticle is sufficiently high. Furthermore, extreme ultraviolet radiation is irradiated to harden the resist pattern in this embodiment, but this resist pattern can be hardened by directly heating the substrate.

[0017]

[Advantages of the Invention]

As described above, with a reticle and its fabrication method of this invention, a reticle is fabricated by forming a resist pattern through the following steps: coating a resist not permeated by vacuum ultraviolet radiation on a substrate, exposing it, and developing it. The pattern-formed resist is used as a reticle in photolithography using vacuum ultraviolet radiation as the light source. Thus, the number of steps required is less than in the conventional fabrication steps of a reticle using a thin Cr film. This reduction in the number of steps reduces the fabrication cost of a reticle. Furthermore, there was a problem that the processing precision was bad because the dimensional shift was caused between the resist pattern dimension and the finally-fabricated Cr pattern in the wet etching step of a thin Cr film as a characteristic of isotropic etching in the conventional method. A reticle can be fabricated with higher precision without the problem of dimensional shift because there is only one step in forming the resist pattern, and no etching step in this invention. Furthermore, in this invention, damage caused by irradiation of vacuum ultraviolet radiation can be prevented because the resist is hardened during the heat-treating of the resist pattern. This contributes to fabricate a reticle with higher reliability. Consequently, this invention greatly improves the fabrication of ultra high-density integrated-circuits because it efficiently operates in a fabrication method

reducing costs and improving precision in photolithography using vacuum ultraviolet radiation.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Drawing describing the structure of a reticle and ArF excimer laser exposure method in the first embodiment of this invention

[Figure 2]

Drawing of characteristics of the ultraviolet radiation permeability of the ArF photo sensitive resist and electron-beam photo sensitive-resist in Figure 1

[Figure 3]

Cross-sectional view of the steps for fabricating the reticle in the first embodiment of this invention.

[Figure 4]

Cross-sectional view of steps for fabricating the reticle in the second embodiment of this invention.

[Figure 5]

Cross-sectional view of steps in the conventional fabrication of a reticle

[Reference Symbols]

11: Quartz substrate
12: Electron-beam photo sensitive-resist
13: Si substrate
14: ArF photo sensitive resist
15: ArF excimer laser
16: Reticle
41: Extreme ultraviolet radiation
51: Thin Cr film

Figure 1

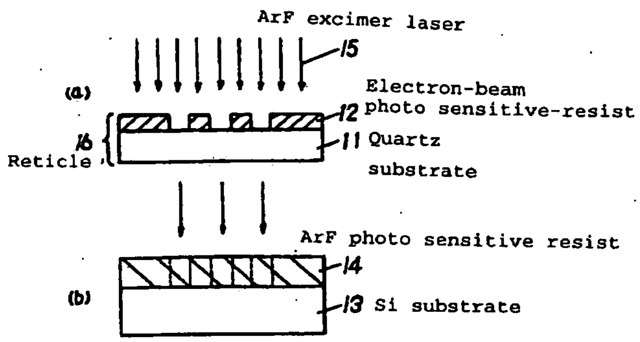


Figure 2

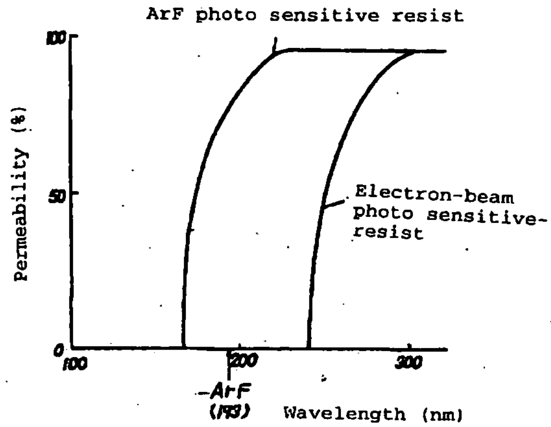


Figure 3

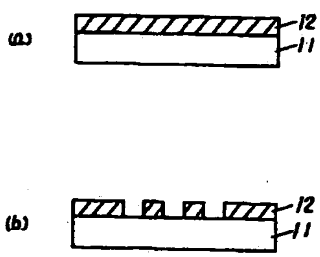


Figure 4

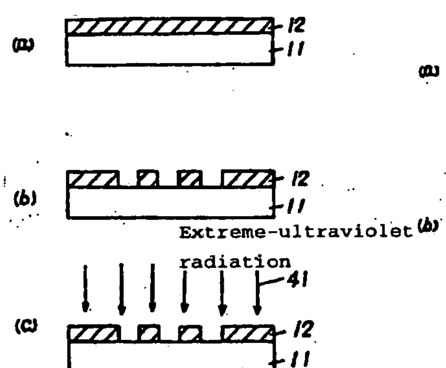
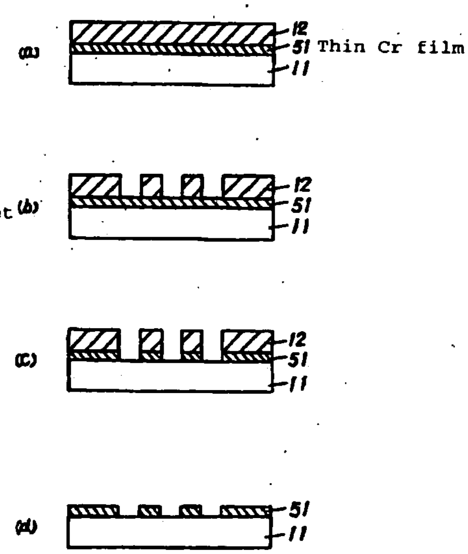


Figure 5



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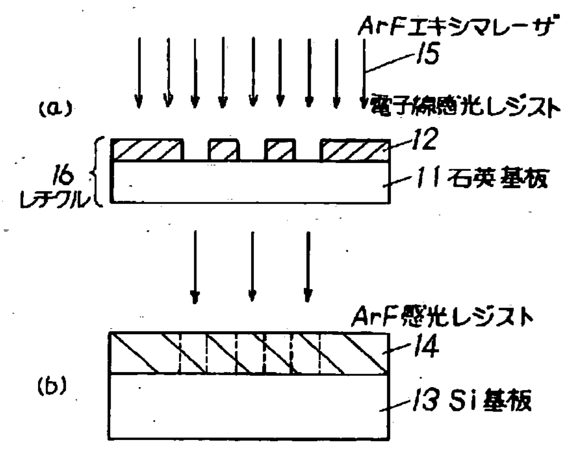
(54)【発明の名称】　レチクルおよびレチクル製造方法

(57)【要約】
【目的】　真空紫外光を用いたリソグラフィにおいて、レチクルを簡易にかつ高精度に製造する。
【構成】　石英基板１１上にＡｒＦエキシマレーザ（１９３ｎｍ）に対して透過率がほぼ０％の電子線感光レジスト１２を塗布し、電子線感光レジスト１２上に電子ビームにより所望のパターンを描画し、現像し、レジストパターンを形成した。この様にして形成したレジストパターンはＡｒＦエキシマレーザリソグラフィにおけるレチクルとして使用することができ、レチクルを簡易にかつ高精度に製造することができた。レジストをパターン形成したレチクル１６上にＡｒＦエキシマレーザ１５を照射して、Ｓｉ基板１３上のＡｒＦ感光レジスト１４を露光して、所望のパターンを高コントラストで転写することができた。



【特許請求の範囲】
【請求項1】ガラス基板上にレジストパターンを有する構造を備えて成ることを特徴とするレチクル。
【請求項2】前記レジストパターンは真空紫外光に対して透過しないことを特徴とする請求項1記載のレチクル。
【請求項3】ガラス基板上にレジストを塗布する工程と、前記レジストを露光する工程と、前記レジストを現像する工程とを備えて成ることを特徴とするレチクル製造方法。
【請求項4】前記レジストは真空紫外光に対して透過しないことを特徴とする請求項3記載のレチクル製造方法。
【請求項5】前記レジストを露光する工程は電子ビームにより描画することを特徴とする請求項3記載のレチクル製造方法。
【請求項6】前記レジストを現像する工程の後に、前記レジストを加熱処理する工程を加えることを特徴とする請求項3記載のレチクル製造方法。
【発明の詳細な説明】
【0001】
【産業上の利用分野】本発明は、半導体デバイスの微細加工のためのフォトリソグラフィ技術に関するものであり、特に、真空紫外光を光源とするフォトリソグラフィにおける、レチクルの構造とレチクルの製造方法に関するものである。
【0002】
【従来の技術】フォトリソグラフィ技術は、レチクルを用いて、ステップアンドリピートでパターンを縮小投影するためスループットが高く、かつ微細パターン形成が可能であることから、ＬＳＩの量産に不可欠な技術である。光の波長をλ、レンズの開口数をＮＡとすると、フォトリソグラフィの解像度Ｒは、$R=k_1\lambda/NA$の関係式が成り立つ。ただし、k_1はレジスト材料、プロセスに依存する定数である。この関係式からわかるように、微細化がすすむにつれ、より短波長の光源を用いたフォトリソグラフィが必要とされている。現在、Ｉ線（３６５ｎｍ）、ＫｒＦエキシマレーザ（２４８ｎｍ）を光源にしたステッパを用いて、超ＬＳＩの開発が行われている。さらに微細な超ＬＳＩを開発するためには、より短波長の光源（真空紫外領域）を用いたステッパが必要不可欠となる。例えば、ＡｒＦエキシマレーザ（１９３ｎｍ）のステッパが考えられる。一方、微細化がすすむにつれて、パターンデータ量の増加に伴うレチクル製造コストの増大、レチクルの加工精度の問題が生じてくる。
【０００３】従来のレチクルの構造は、ガラス基板上の遮光部にＣｒの薄膜を堆積したものである。従来のレチクルの製造方法を（図５）に示す。石英基板１１上にＣｒ薄膜５１を膜厚８０ｎｍ堆積する。前記Ｃｒ薄膜５１上に電子線感光レジスト１２を厚さ５００ｎｍ塗布する（図５（ａ））。電子線感光レジスト１２上に任意のパターンを電子ビームを用いて描画し、現像する（図５（ｂ））。硝酸第２セリウムアンモンと過塩素酸を溶解したエッチング液を用いて、パターン形成した電子線感光レジスト１２をマスクにしてＣｒ薄膜５１をエッチングする（図５（ｃ））。O_2プラズマによる等方性ドライエッチングにより、電子線感光レジスト１２を除去してレチクルを形成する（図５（ｄ））。
【0004】
【発明が解決しようとする課題】上記のような構成では、レチクルの製造工程が、Ｃｒ薄膜堆積、電子ビームリソグラフィ、ウエットエッチング、レジスト除去と工程数が多くなるため、コストが高くなるという問題点を有していた。また、Ｃｒ薄膜のウエットエッチングの工程において、等方性エッチングの性質上、レジストパターン寸法と最終的に形成されるＣｒパターンとの寸法シフトが生じるため、より微細化がすすむとレチクルの加工精度が無視できなくなるという問題点を有していた。
【０００５】本発明は、上記課題を解決するもので、真空紫外領域のフォトリソグラフィにおいて、工程数の少ない、高精度なレチクルの製造方法を提供することを目的としている。
【0006】
【課題を解決するための手段】本発明は、ガラス基板上にレジストパターンを有する構造を備えて成ることを特徴とするレチクルを提供するものである。特に、前記レジストパターンは真空紫外光に対して透過しないことを特徴とする上記のレチクルを提供する。さらに本発明は、ガラス基板上にレジストを塗布する工程と、前記レジストを露光する工程と、前記レジストを現像する工程とを備えて成ることを特徴とするレチクル製造方法を提供するものである。特に、前記レジストは真空紫外光に対して透過しないことを特徴とする上記のレチクル製造方法を提供する。また望ましくは、前記レジストを露光する工程は電子ビームにより描画することを特徴とする上記のレチクル製造方法を提供する。さらに本発明は、前記レジストを現像する工程の後に、前記レジストを加熱処理する工程を加えることを特徴とする上記のレチクル製造方法を提供する。
【0007】
【作用】本発明では、ガラス基板上に真空紫外光に対して透過性を示さないレジストを塗布し、露光、現像し、レジストパターンを形成して、レチクルを製造する。レジストパターンが真空紫外光に対して透過性を示さないから、真空紫外光を用いたフォトリソグラフィにおいては、このレジストパターンがレチクルの遮光部にそのまま成り得る。つまり、真空紫外光を透過しないレジストパターンで形成したレチクルは、従来におけるＣｒ薄膜で形成したレチクルと同様に、高コントラストのパター

ン転写が可能となる。従って、従来法の工程がＣｒ薄膜堆積、電子ビームリソグラフィ、ウエットエッチング、レジスト除去の４工程であるのに対して、本発明のレチクルの製造方法は電子ビームリソグラフィの１工程のみであり、工程数を従来より少なくすることができる。また、従来法ではＣｒ薄膜のウエットエッチングの工程において、等方性エッチングの性質上、レジストパターン寸法と最終的に形成されるＣｒパターンとの寸法シフトが生じるため、加工精度が悪いという問題点があったが、本発明ではエッチング工程がないため、より高精度にレチクルを製造することができる。また本発明ではガラス基板上に形成したレジストパターンを加熱処理することによって、レジストパターンを硬化させるため、真空紫外光の照射による損傷を防止することができる。

【０００８】従って、本発明を用いることによって、真空紫外光を用いたフォトリソグラフィにおいて、簡易で、高精度なレチクル製造に有効に作用する。

【０００９】

【実施例】以下本発明の一実施例のレチクル製造方法について、図面を参照しながら説明する。ここでは、真空紫外光を用いた、特にＡｒＦエキシマレーザを用いたフォトリソグラフィにおけるレチクルの構造とレチクル製造方法について説明する。

【００１０】（図１）は本発明の実施例におけるレチクルの構造とＡｒＦエキシマレーザ露光方法の説明図を示すものである。レチクルの構造は、石英基板１１上に電子線感光レジスト１２をパターン形成したものである。ＡｒＦエキシマレーザ露光方法は、上述した構造のレチクル１６上にＡｒＦエキシマレーザ１５を照射して、Ｓｉ基板１３上に塗布したＡｒＦ感光レジスト１４上にパターン転写を行う。（図２）に前記した電子線感光レジスト１２とＡｒＦ感光レジスト１４の紫外透過特性を示す。図に示すように、電子線感光レジスト１２はＡｒＦ（１９３ｎｍ）に対して透過率がほぼ０％になるようなものを用いて、ＡｒＦ感光レジスト１４は８０％程度の透過率のものを用いた。このようにして、電子線感光レジスト１２はＡｒＦ（１９３ｎｍ）に対して透過しない材料を選択することにより、ＡｒＦエキシマレーザリソグラフィにおいて高コントラストの転写が可能となる。

【００１１】（図３）は本発明の第１の実施例におけるレチクル製造の工程断面図を示すものである。（図２）に示すようにＡｒＦ（１９３ｎｍ）に対して透過率がほぼ０％になるような電子線感光レジスト１２を石英基板１１上に膜厚５００ｎｍ塗布し、９０℃で６０秒間電子線感光レジスト１２を加熱処理した（図３（ａ））。石英基板１１上に塗布した電子線感光レジスト１２上に電子線を照射し、所望のパターンを描画し、電子線感光レジスト１２を現像して、レジストパターンを形成し、レチクルを製造した（図３（ｂ））。

【００１２】以上のように、本実施例によれば、石英基板上に形成したレジストパターンがＡｒＦエキシマレーザに対して透過性を示さないから、ＡｒＦエキシマレーザを用いたフォトリソグラフィにおいては、このレジストパターンがレチクルの遮光部にそのまま成り得る。つまり、本実施例におけるＡｒＦエキシマレーザを透過しないレジストパターンで形成したレチクルは、従来におけるＣｒ薄膜で形成したレチクルと同様に、高コントラストのパターン転写が可能となった。従って、従来法の工程が石英基板上のＣｒ薄膜堆積、電子ビームリソグラフィによるパターン形成、Ｃｒ薄膜のウエットエッチング、レジスト除去の４工程であるのに対して、本実施例のレチクルの製造方法は電子ビームリソグラフィによるパターン形成の１工程のみであり、工程数を従来より少なくすることができた。また、従来法ではＣｒ薄膜のウエットエッチングの工程において、等方性エッチングの性質上、レジストパターン寸法と最終的に形成されるＣｒパターンとの寸法シフトが生じるため、加工精度が悪いという問題点があったが、本実施例ではエッチング工程がないため寸法シフトの問題がなく、より高精度にレチクルを製造することができた。

【００１３】なお、本実施例において、真空紫外光、特にＡｒＦエキシマレーザ（１９３ｎｍ）を光源にしたフォトリソグラフィにおけるレチクルの構造と製造方法を示したが、他の波長の光を光源にした場合においても同様に石英基板上にパターン形成したレジストが光源として用いる光に対して透過率がほぼ０％にさえなればよい。また、本実施例では石英基板上のレジストのパターン形成に電子ビームリソグラフィを用いたが、レジストが本レチクルのパターン転写の光源として用いる光に対して透過率がほぼ０％になるという条件を満たしていればフォトリソグラフィを用いてもよい。また、本実施例では基板に石英を用いたが、本レチクルのパターン転写の光源として用いる光に対して透過率が十分に高ければ他のガラス材料を用いてもよい。

【００１４】（図４）は本発明の第２の実施例におけるレチクル製造の工程断面図を示すものである。（図２）に示すようにＡｒＦ（１９３ｎｍ）に対して透過率がほぼ０％になるような電子線感光レジスト１２を石英基板１１上に膜厚５００ｎｍ塗布し、９０℃で６０秒間電子線感光レジスト１２を加熱処理した（図４（ａ））。石英基板１１上に塗布した電子線感光レジスト１２上に電子線を照射し、所望のパターンを描画し、電子線感光レジスト１２を現像して、レジストパターンを形成した（図４（ｂ））。パターン形成した電子線感光レジスト１２上に遠紫外線４１を照射して、電子線感光レジスト１２を２００℃で１２０秒間加熱処理して、電子線感光レジスト１２を硬化させて、レチクルを製造した（図４（ｃ））。

【００１５】以上のように、本実施例によれば、石英基板上に形成したレジストパターンがＡｒＦエキシマレー

ザに対して透過性を示さないから、ＡｒＦエキシマレーザを用いたフォトリソグラフィにおいては、このレジストパターンがレチクルの遮光部にそのまま成り得る。つまり、本実施例におけるＡｒＦエキシマレーザを透過しないレジストパターンで形成したレチクルは、従来におけるＣｒ薄膜で形成したレチクルと同様に、高コントラストのパターン転写が可能となった。従って、従来法の工程が石英基板上のＣｒ薄膜堆積、電子ビームリソグラフィによるパターン形成、Ｃｒ薄膜のウエットエッチング、レジスト除去の４工程であるのに対して、本実施例のレチクルの製造方法は電子ビームリソグラフィによるパターン形成の１工程のみであり、工程数を従来より少なくすることができた。また、従来法ではＣｒ薄膜のウエットエッチングの工程において、等方性エッチングの性質上、レジストパターン寸法と最終的に形成されるＣｒパターンとの寸法シフトが生じるため、加工精度が悪いという問題点があったが、本実施例ではエッチング工程がないため寸法シフトの問題がなく、より高精度にレチクルを製造することができた。また特に、本実施例では、レジストパターン形成した後、レジスト上に遠紫外線を照射して、レジストを硬化したため、ＡｒＦエキシマレーザ照射による損傷がなく、レチクルの信頼性を向上することができた。

【００１６】なお、本実施例において、真空紫外光、特にＡｒＦエキシマレーザ（１９３nm）を光源にしたフォトリソグラフィにおけるレチクルの構造と製造方法を示したが、他の波長の光を光源にした場合においても同様に石英基板上にパターン形成したレジストが光源として用いる光に対して透過率がほぼ０％にさえなればよい。また、本実施例では石英基板上のレジストのパターン形成に電子ビームリソグラフィを用いたが、レジストが本レチクルのパターン転写の光源として用いる光に対して透過率がほぼ０％になるという条件を満たしていればフォトリソグラフィを用いてもよい。また、本実施例では基板に石英を用いたが、本レチクルのパターン転写の光源として用いる光に対して透過率が十分に高ければ他のガラス材料を用いてもよい。また、本実施例ではレジストパターンの硬化に遠紫外線の照射を行ったが、基板を直接加熱してレジストパターンを硬化させてもよい。

【００１７】

【発明の効果】以上説明したように、本発明のレチクルおよびレチクル製造方法によれば、ガラス基板上に真空紫外光に対して透過性を示さないレジストを塗布し、露光、現像し、レジストパターンを形成し、パターン形成したレジストをそのまま真空紫外光を光源に用いたフォトリソグラフィにおけるレチクルとして用いるため、従来法のＣｒ薄膜を用いたレチクルの製造工程より工程数を減少させることできる。この工程数の減少によりレチクル製造コストの削減に大きく貢献する。また、従来法ではＣｒ薄膜のウエットエッチングの工程において、等方性エッチングの性質上、レジストパターン寸法と最終的に形成されるＣｒパターンとの寸法シフトが生じるため、加工精度が悪いという問題点があったが、本発明ではレジストのパターン形成の工程のみで、エッチング工程がないため寸法シフトの問題がなく、より高精度にレチクルを製造することができる。また特に、本発明において、パターン形成したレジストを加熱処理する工程は、レジストを硬化させ、真空紫外光の照射による損傷を防止することができ、信頼性の高いレチクルの製造に寄与することができる。従って、本発明を用いることによって、真空紫外光を用いたフォトリソグラフィにおいて、低コストで、高精度なレチクル製造に有効に作用するので、超高密度集積回路の製造に大きく寄与することができる。

【図面の簡単な説明】

【図１】本発明の第１の実施例におけるレチクルの構造とＡｒＦエキシマレーザ露光方法の説明図

【図２】図１におけるＡｒＦ感光レジストと電子線感光レジストの紫外透過特性図

【図３】本発明の第１の実施例におけるレチクル製造の工程断面図

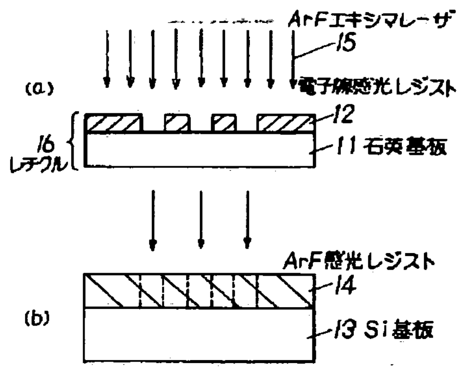
【図４】本発明の第２の実施例におけるレチクル製造の工程断面図

【図５】従来のレチクル製造の工程断面図

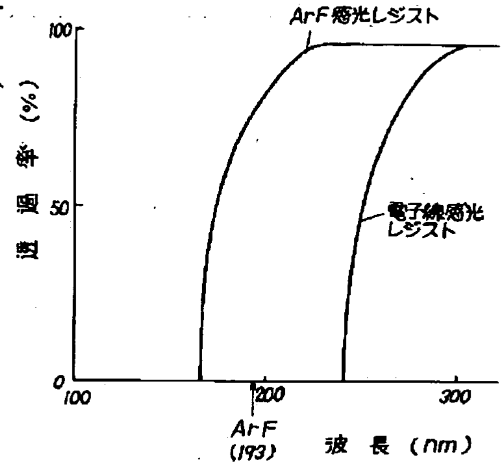
【符号の説明】

１１　石英基板
１２　電子線感光レジスト
１３　シリコン基板
１４　ＡｒＦ感光レジスト
１５　ＡｒＦエキシマレーザ
１６　レチクル
４１　遠紫外線
５１　Ｃｒ薄膜

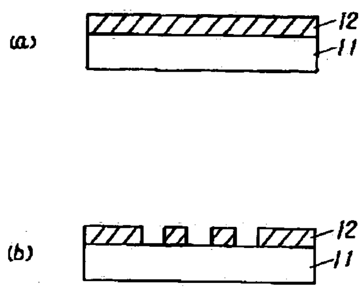
【図1】



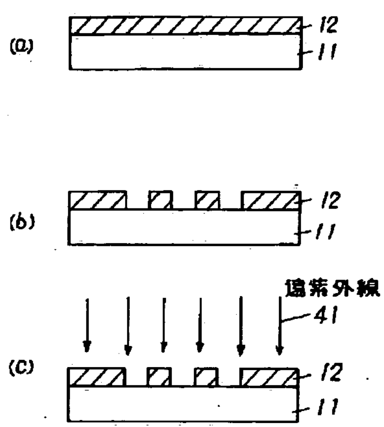
【図2】



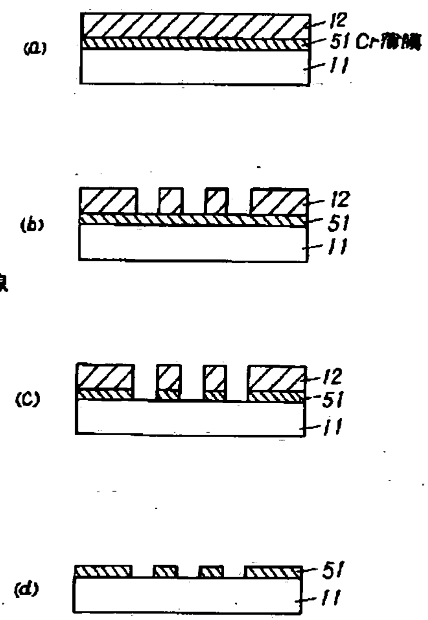
【図3】



【図4】



【図5】



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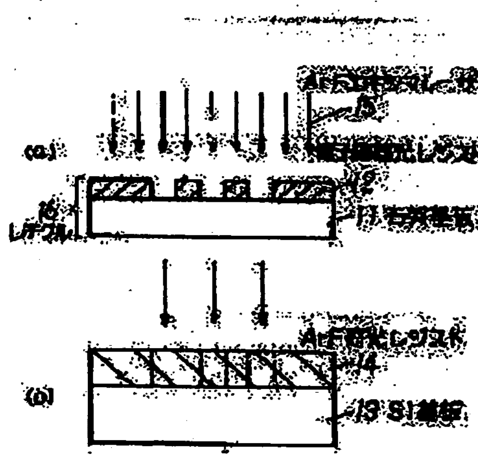
(54) RETICLE AND ITS PRODUCTION

(57)Abstract:

PURPOSE: To easily produce a reticle with high precision in the lithography using vacuum UV.

CONSTITUTION: An electron beam-sensitive resist 12 having almost 0% transmissivity to an ArF excimer laser (193nm) is applied on a quartz substrate 11, and a desired pattern is drawn on the resist 12 by an electron beam and developed to form a resist pattern. The resist pattern thus formed is used as a reticle in ArF excimer laser lithography, and the reticle is easily produced with high precision. The reticle 16 is irradiated with an ArF excimer laser 15 to expose an ArF photosensitive resist 14 on an Si substrate 13, and a desired pattern is transferred with high contrast.



193nm.

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2.   shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the manufacture method of the structure of a reticle, and a reticle in the photolithography which uses vacuum-ultraviolet light as the light source especially about the photolithography technology for micro processing of a semiconductor device.
[0002]
[Description of the Prior Art] Since photolithography technology carries out reduction projection of the pattern by step-and-repeat one using a reticle and detailed pattern formation is [its throughput is high and] possible for it, it is technology indispensable to the mass production of LSI. If numerical aperture of lambda and a lens is set to NA for the wavelength of light, as for the resolution R of a photolithography, the relational expression of R=k1 lambda/NA will be realized. However, k1 is a constant depending on resist material and a process. The photolithography using the light source of short wavelength is needed more as shown in this relational expression and detailed-ization progresses. Now, development of a VLSI is performed using the stepper which used I line (365nm) and the KrF excimer laser (248nm) as the light source. In order to develop a still more detailed VLSI, the stepper which used the light source (vacuum-ultraviolet field) of short wavelength more becomes indispensable. For example, the stepper of an ArF excimer laser (193nm) can be considered. On the other hand, the problem of increase of the reticle manufacturing cost accompanying the increase in the pattern amount of data and the process tolerance of a reticle arises as detailed-ization progresses.
[0003] The structure of the conventional reticle deposits the thin film of Cr on the shading section on a glass substrate. The manufacture method of the conventional reticle is shown in (drawing 5). The Cr thin film 51 is deposited 80nm of thickness on the quartz substrate 11. The electron ray sensitization resist 12 is applied 500nm in thickness on the aforementioned Cr thin film 51 (drawing 5 (a)). Arbitrary patterns are drawn and developed using an electron beam on the electron ray sensitization resist 12 (drawing 5 (b)). The electron ray sensitization resist 12 which carried out pattern formation is used as a mask using the etching reagent which dissolved 2nd cerium Amon of a nitric acid, and perchloric acid, and the Cr thin film 51 is ***********ed (drawing 5 (c)). By the isotropic dry etching by O2 plasma, the electron ray sensitization resist 12 is removed and a reticle is formed (drawing 5 (d)).
[0004]
[Problem(s) to be Solved by the Invention] With the above composition, since Cr thin film deposition, electron beam lithography, wet etching, and the resist removal and number of processes of the manufacturing process of a reticle increased, it had the trouble that cost became high. Moreover, in the process of the wet etching of Cr thin film, on the property of isotropic etching, since the pattern shift of a a resist pattern size and Cr pattern finally formed arose, when detailed-ization progressed more, it had the trouble of it becoming impossible to disregard the process tolerance of a reticle.
[0005] this invention solves th ab ve-mentioned technical problem, and aims at offering the manufacture method f a highly precis reticle with few processes in the photolithography of a vacuum-ultraviolet field.

[0006]
[Means for Solving the Problem] The reticle characterized by equipping this invention with the structure of having a resist pattern, and changing on a glass substrate is offered. Especially, the above-mentioned reticle characterized by not penetrating the aforementioned resist pattern to vacuum-ultraviolet light is offered. Furthermore, the reticle manufacture method characterized by equipping this invention with the process which applies a resist, the process which exposes the aforementioned resist, and the process which develops the aforementioned resist, and changing on a glass substrate is offered. Especially, the aforementioned resist offers the above-mentioned reticle manufacture method characterized by not penetrating to vacuum-ultraviolet light. Moreover, the above-mentioned reticle manufacture method characterized by the process which exposes the aforementioned resist drawing with an electron beam is offered desirably. Furthermore, this invention offers the above-mentioned reticle manufacture method characterized by adding the process which heat-treats the aforementioned resist after the process which develops the aforementioned resist.
[0007]
[Function] In this invention, on a glass substrate, the resist which does not show permeability to vacuum-ultraviolet light is applied and developed [expose and], a resist pattern is formed, and a reticle is manufactured. Since a resist pattern does not show permeability to vacuum-ultraviolet light, in the photolithography using vacuum-ultraviolet light, this resist pattern can grow into the shading section of a reticle as it is. That is, the pattern imprint of high contrast of the reticle formed by the resist pattern which does not penetrate vacuum-ultraviolet light is attained like the reticle formed by Cr thin film in the former. Therefore, to the processes of a conventional method being Cr thin film deposition, electron beam lithography, wet etching, and four processes of resist removal, the manufacture method of the reticle of this invention is only one process of electron beam lithography, and can make the number of processes fewer than before. Moreover, in the process of the wet etching of Cr thin film, on the property of isotropic etching, since the pattern shift of a resist pattern size and Cr pattern finally formed arose, although there was a trouble that a process tolerance was bad, since there is no etching process, at a conventional method, a reticle can be manufactured more to high degree of accuracy by this invention. Moreover, in this invention, since a resist pattern is stiffened by heat-treating the resist pattern formed on the glass substrate, the injury by irradiation of vacuum-ultraviolet light can be prevented.
[0008] Therefore, in the photolithography using vacuum-ultraviolet light, it acts effective in simple and highly precise reticle manufacture by using this invention.
[0009]
[Example] The reticle manufacture method of one example of this invention is explained below, referring to a drawing. Here, the structure and the reticle manufacture method of a reticle in the photolithography especially using the ArF excimer laser of having used vacuum-ultraviolet light are explained.
[0010] (Drawing 1) shows the structure of a reticle and explanatory drawing of the ArF excimer laser exposure method in the example of this invention. The structure of a reticle carries out pattern formation of the electron ray sensitization resist 12 on the quartz substrate 11. The ArF excimer laser exposure method irradiates the ArF excimer laser 15 on the reticle 16 of the structure mentioned above, and performs a pattern imprint on the ArF sensitization resist 14 applied on the Si substrate 13. The ultraviolet transparency property of the electron ray sensitization resist 12 and the ArF sensitization resist 14 described above to (drawing 2) is shown. As shown in drawing, in the electron ray sensitization resist 12, the ArF sensitization resist 14 used the thing of about 80% of permeability using that from which permeability becomes about 0% to ArF (193nm). Thus, in ArF excimer laser lithography, the imprint of high contrast of the electron ray sensitization resist 12 is attained by choosing the material which is not penetrated to ArF (193nm).
[0011] (Drawing 3) shows the reticle production-process cross section in the 1st example of this invention. As shown in (drawing 2), the electron ray sensitizati n resist 12 from which permeability becomes about 0% to ArF (193nm) was applied 500nm of thickness on the quartz substrate 11, and the electron ray sensitization resist 12 was heat-treated for 60 seconds at 90 degrees C (drawing 3 (a)). The

electron ray was irradiated on the electron ray sensitization resist 12 applied on the quartz substrate 11, the desired pattern was drawn, the electron ray sensitization resist 12 was developed, the resist pattern was formed, and the reticle was manufactured (drawing 3 (b)).

[0012] As mentioned above, according to this example, since the resist pattern formed on the quartz substrate does not show permeability to an ArF excimer laser, in the photolithography using the ArF excimer laser, this resist pattern can grow into the shading section of a reticle as it is. That is, the pattern imprint of high contrast of the reticle formed by the resist pattern which does not penetrate the ArF excimer laser in this example was attained like the reticle formed by Cr thin film in the former. Therefore, to the processes of a conventional method being the wet etching of Cr thin film deposition on a quartz substrate, the pattern formation by electron beam lithography, and Cr thin film, and four processes of resist removal, the manufacture method of the reticle of this example is only one process of the pattern formation by electron beam lithography, and was able to make the number of processes fewer than before. Moreover, in the process of the wet etching of Cr thin film, on the property of isotropic etching, since the pattern shift of a resist pattern size and Cr pattern finally formed arose, although there was a trouble that a process tolerance was bad, since there is no etching process, there is no problem of a pattern shift, and the reticle was able to be manufactured more to high degree of accuracy by this example at the conventional method.

[0013] In addition, in this example, although the structure and the manufacture method of a reticle in the photolithography which used vacuum-ultraviolet light, especially the ArF excimer laser (193nm) as the light source were shown, when light of other wavelength is used as the light source, permeability should just become even about 0% to the light which the resist which carried out pattern formation on the quartz substrate similarly uses as the light source. Moreover, although electron beam lithography was used for the pattern formation of the resist on a quartz substrate in this example, as long as the resist fulfills the conditions that permeability becomes about 0% to the light used as the light source of a pattern imprint of this reticle, you may use a photolithography. Moreover, to the light used as the light source of a pattern imprint of this reticle, although the quartz was used for the substrate in this example, as long as permeability is fully high, you may use other glass material.

[0014] (Drawing 4) shows the reticle production-process cross section in the 2nd example of this invention. As shown in (drawing 2), the electron ray sensitization resist 12 from which permeability becomes about 0% to ArF (193nm) was applied 500nm of thickness on the quartz substrate 11, and the electron ray sensitization resist 12 was heat-treated for 60 seconds at 90 degrees C (drawing 4 (a)). The electron ray was irradiated on the electron ray sensitization resist 12 applied on the quartz substrate 11, the desired pattern was drawn, the electron ray sensitization resist 12 was developed, and the resist pattern was formed (drawing 4 (b)). Far ultraviolet rays 41 were irradiated on the electron ray sensitization resist 12 which carried out pattern formation, the electron ray sensitization resist 12 was heat-treated for 120 seconds at 200 degrees C, the electron ray sensitization resist 12 was stiffened, and the reticle was manufactured (drawing 4 (c)).

[0015] As mentioned above, according to this example, since the resist pattern formed on the quartz substrate does not show permeability to an ArF excimer laser, in the photolithography using the ArF excimer laser, this resist pattern can grow into the shading section of a reticle as it is. That is, the pattern imprint of high contrast of the reticle formed by the resist pattern which does not penetrate the ArF excimer laser in this example was attained like the reticle formed by Cr thin film in the former. Therefore, to the processes of a conventional method being the wet etching of Cr thin film deposition on a quartz substrate, the pattern formation by electron beam lithography, and Cr thin film, and four processes of resist removal, the manufacture method of the reticle of this example is only one process of the pattern formation by electron beam lithography, and was able to make the number of processes fewer than before. Moreover, in the process of the wet etching of Cr thin film, on the property of isotropic etching, since the pattern shift of a resist pattern size and Cr pattern finally formed arose, although there was a trouble that a process tolerance was bad, since there is no etching process, there is no problem of a pattern shift, and the reticle was able to be manufactured more to high degree of accuracy by this example at the conventional method. Moreover, especially, by this example, since far

ultraviolet rays were irradiated on the resist and the resist was hardened after carrying out resist pattern formation, there is no injury by ArF excimer laser irradiation, and the reliability of a reticle was able to be improved.

[0016] In addition, in this example, although the structure and the manufacture method of a reticle in the photolithography which used vacuum-ultraviolet light, especially the ArF excimer laser (193nm) as the light source were shown, when light of other wavelength is used as the light source, permeability should just become even about 0% to the light which the resist which carried out pattern formation on the quartz substrate similarly uses as the light source. Moreover, although electron beam lithography was used for the pattern formation of the resist on a quartz substrate in this example, as long as the resist fulfills the conditions that permeability becomes about 0% to the light used as the light source of a pattern imprint of this reticle, you may use a photolithography. Moreover, to the light used as the light source f a pattern imprint of this reticle, although the quartz was used for the substrate in this example, as long as permeability is fully high, you may use other glass material. Moreover, although far ultraviolet rays were irradiated in this example at hardening of a resist pattern, a substrate may be heated directly and a resist pattern may be stiffened.

[0017]

[Effect of the Invention] as explained above, in order to use the resist which exposed and developed [apply and] the resist which does not show permeability to vacuum-ultraviolet light on a glass substrate, and formed and carried out pattern formation of the resist pattern as it is as a reticle in the photolithography which used vacuum-ultraviolet light for the light source according to the reticle and the reticle manufacture method of this invention, the number of processes is decreased from the manufacturing process of the reticle using Cr thin film of a conventional method -- things can be carried out It contributes to curtailment of a reticle manufacturing cost greatly by reduction of this number of processes. Moreover, in the process of the wet etching of Cr thin film, on the property of isotropic etching, since the pattern shift of a resist pattern size and Cr pattern finally formed arose, although there was a trouble that a process tolerance was bad, since there is no etching process, there is no problem of a pattern shift, and a reticle can be manufactured more to high degree of accuracy only at the process of the pattern formation of a resist by this invention at a conventional method. Moreover, especially the process that heat-treats the resist which carried out pattern formation in this invention can stiffen a resist, can prevent the injury by irradiation of vacuum-ultraviolet light, and can be contributed to manufacture of a reliable reticle. Therefore, since it acts effective in highly precise reticle manufacture by the low cost in the photolithography using vacuum-ultraviolet light by using this invention, it can contribute to manufacture of super-large scale integration greatly.

NOTICES

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Structure of a reticle and explanatory drawing of the ArF excimer laser exposure method in the 1st example of this invention
[Drawing 2] The ultraviolet transparency property view of an ArF sensitization resist and an electron ray sensitization resist in drawing 1
[Drawing 3] The reticle production-process cross section in the 1st example of this invention
[Drawing 4] The reticle production-process cross section in the 2nd example of this invention
[Drawing 5] The conventional reticle production-process cross section
[Description of Notations]
11 Quartz Substrate
12 Electron Ray Sensitization Resist
13 Silicon Substrate
14 ArF Sensitization Resist
15 ArF Excimer Laser
16 Reticle
41 Far Ultraviolet Rays
51 Cr Thin Film

[Translation done.]

* NOTICES *

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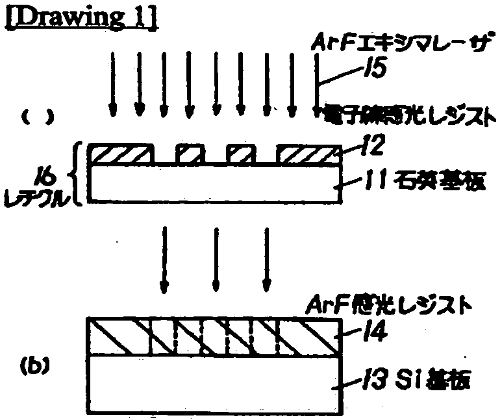
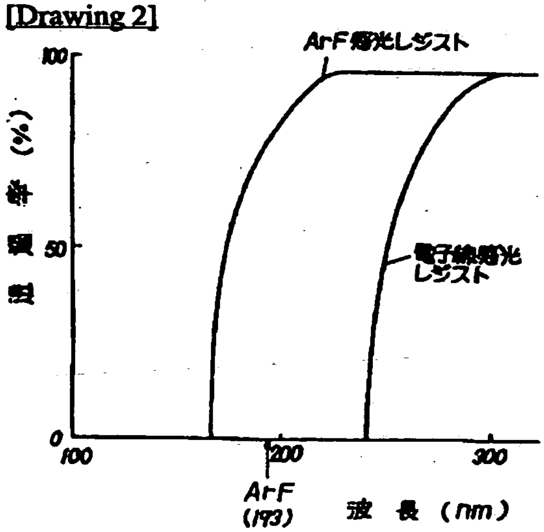
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2. * shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



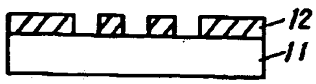
[Drawing 2]



[Drawing 3]

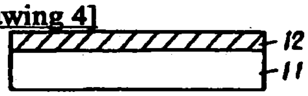
(a)

(b)



[Drawing 4]

(a)



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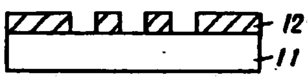

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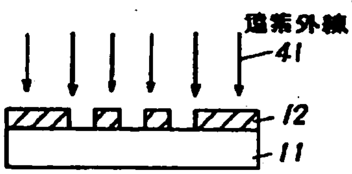
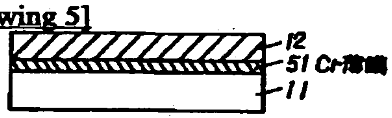


[Drawing 5]

(a)



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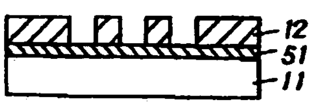

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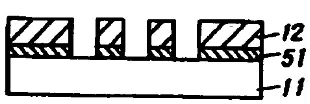
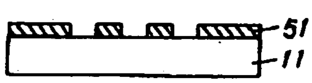


(d)



[Translation done.]